

STUDY GUIDE

GROUNDWATER

SUBCLASS G

WISCONSIN DEPARTMENT OF NATURAL RESOURCES
BUREAU OF INTEGRATED SCIENCE SERVICES
P. O. BOX 7921
MADISON, WI 53707

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PREFACE

This operator's study guide represents the results of an ambitious program. Operators of wastewater and water supply facilities, regulators, educators and local officials, jointly prepared the objectives and exam questions for this subgrade.

The objectives in this study guide have been organized into modules, and within each module they are grouped by major concepts.

HOW TO USE THESE OBJECTIVES WITH REFERENCES

In preparation for the exams, you should:

1. Read all the objectives that apply to the grade level desired and write down the answers to the objectives that readily come to mind.
2. Use the references at the end of the study guide to look-up answers you don't know. This one set of references covers all of the objectives.
3. Write down the answers found in the references to those objectives you could not answer from memory.
4. Review all answered objectives until you can answer each from memory.

IT IS ADVISABLE THAT YOU ATTEND SOME FORM OF FORMAL TRAINING IN THIS PROCESS BEFORE ATTEMPTING THE CERTIFICATION EXAM.

Choosing A Test Date

Before you choose a test date, consider the training opportunities available in your area. A listing of training opportunities and exam dates can be found in the annual DNR "Certified Operator," or by contacting your DNR District operator certification coordinator.

GROUNDWATER

A: PRINCIPLE, STRUCTURE AND FUNCTION

CONCEPT: PRINCIPLE OF GROUNDWATER

1. Describe the movement of water through the hydrologic cycle.
2. Sketch a diagram of the hydrologic cycle and label the parts.
3. Define the following terms:
 - A. Water Table
 - B. Permeability
 - C. Infiltration
 - D. Aquifer
 - E. Impervious Layer
 - F. Artesian Well
 - G. Recharge Area
 - H. Discharge Area
4. State characteristics of a good aquifer and identify different types of formations which would serve as good aquifers.
5. List the factors which affect the depth at which groundwater is located.
6. Explain how water table levels are affected by seasonal changes.
7. List factors which affect the chemical and biological quality of groundwater.

8. Describe the health or aesthetic significance of the following elements and compounds:
 - A. Iron
 - B. Manganese
 - C. Hydrogen Sulfide
 - D. Nitrate
 - E. Fluoride
 - F. Calcium
 - G. Magnesium
 - H. Dissolved Oxygen And Dissolved air
 - I. Sodium
9. State the principal purpose for the chlorination of water.

CONCEPT: STRUCTURE AND FUNCTION

10. List the six common types of wells, and identify which are suitable for municipal use.
11. Discuss sanitary hazards that should not be near a well.
12. Given a cross-sectional sketch of a typical well, identify the air line, pressure gauge, air vent, static water level, pumping water level, drawdown, and cone of depression.
13. Describe the purpose of a well casing.
14. Explain why wells are grouted.
15. Explain the purpose of a well screen.
16. Given a diagram, label various features in a typical pumphouse.
17. Given a diagram of a vertical turbine pump, label the parts.
18. Describe the functions of the following parts of a vertical turbine pump:
 - A. Motor
 - B. Pump Head
 - C. Impeller
 - D. Bowl Assembly
 - E. Packing
 - F. Shaft
 - G. Thrust Bearing
 - H. Strainer
 - I. Spider

19. Describe how a vertical turbine pump works.
20. From a sketch, identify the components of a direct acid (fluoride) feed system.
21. Discuss when a diluted acid (fluoride) feed system is used, and what additional equipment is needed for this type system.
22. From a sketch, identify and state the functions of the following components of a hypochlorination system:
 - A. Hypochlorite Solution Container
 - B. Suction Line, With Strainer
 - C. Diaphragm Type Positive Displacement Pump
 - D. Discharge Line
 - E. Anti-Siphon Device
 - F. Water Main Connection And Shut-Off Valve
23. Given a sketch of a solution feed gas chlorination system, identify and state the function of the following components:
 - A. Chlorine Gas Cylinder
 - B. Yoke Unit
 - C. Control Unit (Chlorinator)
 - D. Gas Vacuum Line
 - E. Booster Pump and Piping
24. Describe the operation of a solution-feed vacuum type gas chlorination system.

MODULE B: OPERATION AND MAINTENANCE

CONCEPT: OPERATION

25. Explain what a wellhead protection plan is, why it is important, and when it is required.
26. List the negative side effects of excessive groundwater use.
27. Site remedies that help eliminate undesirable side effects of excessive groundwater use.
28. Discuss the problems hard water can create for a utility.

29. Explain why adjacent wells may have different water qualities.
30. Explain the effect well pumping can have on adjacent wells.
31. List the reasons for a rise or drop in the following:
 - A. Static Water Level
 - B. Pumping Water Level
 - C. Specific Capacity
32. Describe the methods available to determine water levels in wells.
33. State how often water levels should be determined.
34. Identify two forms of incrustations found on well screens.
35. Identify considerations to be taken before starting a vertical turbine pump.
36. Identify suitable injection points for the following chemicals:
 - A. Sodium Hypochlorite
 - B. Calcium Hypochlorite
 - C. Gaseous Chlorine
 - D. Hydrofluosilicic Acid
 - E. Polyphosphate
 - F. Sodium Hydroxide
37. Describe how a chemical feed pump capacity can be controlled by:
 - A. Length Of Stroke
 - B. Number Of Strokes
38. Define the following terms:
 - A. Dosage
 - B. Chlorine Demand
 - C. Free Chlorine Residual
 - D. Combined Chlorine Residual
 - E. Total Chlorine Residual
39. Identify the various forms in which chlorine is available and the approximate percent available chlorine for each form.

40. Describe the physical properties (color, density, odor, etc.) of the following forms of chlorine:
 - A. Gas
 - B. Solid (Calcium Hypochlorite)
 - C. Liquid (Sodium Hypochlorite)
41. Discuss the effect drinking water containing the proper amount of fluoride has on teeth during the years of tooth development.
42. Describe the effect on teeth of drinking water containing fluoride greater than the maximum contaminant level (MCL) during the years of tooth development.
43. Discuss the purposes for adding polyphosphates to water.
44. Discuss problems with the use of polyphosphates.
45. Explain the purposes for adding sodium hydroxide.

CONCEPT: MAINTENANCE

46. Describe good pump operational and maintenance procedures in relation to the following:
 - A. Priming
 - B. Packing
 - C. Bearings
 - D. Alignment
47. Outline a preventive maintenance program for a positive displacement pump feeding hypochlorite.
48. Explain why lead or asbestos washers should never be reused.
49. Discuss the symptoms of old packing and cavitation in pumps.
50. Describe the methods of well rehabilitation.
51. Explain the types and importance of stand-by power availability at a treatment plant.
52. State how often stand-by power should be operated.

MODULE C: MONITORING AND TROUBLESHOOTING

CONCEPT: MONITORING

53. Differentiate between "primary" and "secondary" drinking water standards.
54. Identify secondary standards for the following:
 - A. Iron
 - B. Manganese
 - C. Hydrogen Sulfide
55. State the monitoring requirements for the following:
 - A. Inorganic Chemicals (except Lead and Copper)
 - B. Lead and Copper
 - C. Synthetic Organic Chemicals
 - D. Disinfection/Disinfection By-Products
 - E. Volatile Organic Compounds
 - F. Radioactivity
56. Identify the maximum contaminant levels (MCL's) for fluoride and nitrate.
57. Describe a good bacteriological sampling program.
58. Indicate how often bacteriological samples should be collected from a well if the water is chlorinated.
59. State the holding time for bacteriological samples.
60. Given hypothetical data, correctly complete a bacteriological report form.
61. Describe the procedure to follow when a bacteriological sample is deemed "unsafe".
62. Identify the laboratories where bacteriological samples may be analyzed.
63. List the circumstances where public notification is required.
64. State how often samples must be sent to the State Laboratory of Hygiene for fluoride analysis.

65. State how often an operator must test the chlorine residual in a groundwater distribution system if chlorine is being added.
66. Specify the minimum free chlorine residual that must be maintained throughout the system if a groundwater source is required to be chlorinated.
67. Specify how often an operator must test for fluoride if fluoride is being added to the water.
68. Identify the sample container requirements used in collecting fluoride samples.
69. Identify values for the following:
 - A. Optimal Level For Fluoride
 - B. Range Within Which Fluoride Should Be Maintained
70. Define pH, and explain its importance to water supply operators.
71. List the acidic, neutral, and basic values for pH.
72. Identify methods to control corrosive water.
73. Discuss the various methods used to determine the stability of water with respect to calcium carbonate saturation.
74. Describe the calculations involved in using the Langelier Index and the Calcium Carbonate Solubility Curve in determining corrosive or depositing properties of a particular water.

CONCEPT: TROUBLESHOOTING

75. Explain remedial measures for drops in the static water level, pumping water level, and specific capacity.
76. List possible causes and remedies for the following pump symptoms:
 - A. Short Bearing Life
 - B. Cavitation
 - C. Short Packing Life
 - D. Vibrating Pump
 - E. Pump Loses Prime
 - F. Reduced Rate Of Discharge
 - G. Pumps Will Not Start

77. Describe the possible reasons for a well pump breaking suction.

MODULE D: SAFETY AND CALCULATIONS

CONCEPT: SAFETY

78. Describe the safety considerations when preparing a solution of hydrofluosilicic acid.
79. List the rules concerning chlorine storage.
80. Describe a method of detecting chlorine gas leaks.

CONCEPT: CALCULATIONS

81. Using a pressure gauge that reads in feet, determine the static water level, pumping water level, and drawdown in a well.
82. Given the static water level, pumping water level and pumping rate, calculate the specific capacity of a well.
83. Given water meter readings from the well house meter, estimate the daily pumpage or given pumping rate (calculate total gallons).
84. Given a graph of water pumpage versus volume of chemical used, determine the calculated dosages when volume of chemical and pumping rates are given.

RESOURCES

1. SMALL WATER SYSTEM OPERATION AND MAINTENANCE. 1st Edition (1990). Kenneth D. Kerri. California State University, 6000 J Street, Sacramento, CA 95819-6025. Phone (916) 278-6142.
2. STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER. 17th Edition (1989), 18th Edition (1992). Joint Publication of: American Public Health Association; American Water Works Association; and, Water Environment Federation (Old WPCF). Publication Office: American Public Health Association, 1015 Fifteenth Street NW, Washington, DC 20005.
3. WISCONSIN ADMINISTRATIVE CODE NR 809 (OLD 109) SAFE DRINKING WATER. Wisconsin Department of Natural Resources, Attn: Ken Cramer, P.O. Box 7921, Madison WI 53707.
4. WISCONSIN ADMINISTRATIVE CODE NR 811 REQUIREMENTS FOR THE OPERATION AND DESIGN OF COMMUNITY WATER SYSTEMS. Wisconsin Department of Natural Resources, Attn: Ken Cramer, P.O. Box 7921, Madison, WI 53707.
5. WELLHEAD PROTECTION: AN OUNCE OF PREVENTION. PUBL-WR-303 92 (1992) Department of Natural Resources, Bureau of Water Supply, P.O. Box 7921, Madison, WI 53707.

THE FOLLOWING ADDITIONAL RESOURCES CAN BE OBTAINED FROM:

AMERICAN WATER WORKS ASSOCIATION
MEMBER SERVICE DEPARTMENT
6666 W. QUINCY AVENUE
DENVER, CO 80235
(303) 794-7711

1-800-92-ORDER (CHARGE CARD CUSTOMERS OR AWWA MEMBERS ONLY)

6. BASIC MANAGEMENT PRINCIPLES FOR SMALL WATER SYSTEMS. AWWA No. 20222 (1982).
7. BEFORE THE WELL RUNS DRY - VOLUMES I AND II. VOLUME I, AWWA No. 20224 (1984). VOLUME II, AWWA No. 20225 (1984).
8. CORROSION CONTROL FOR OPERATORS. AWWA No. 20232 (1986).
9. CROSS-CONNECTION AND BACKFLOW PREVENTION. Gustave J. Angele. AWWA No. 20106 (1974).

10. DISINFECTION BY-PRODUCTS: CURRENT PERSPECTIVES. AWWA No. 20032 (1989).
11. IMPROVING WELL AND PUMP EFFICIENCY. Otto J. Helweg, Verne H. Scott, and Joseph C. Scalmanini. AWWA No. 20167 (1983).
12. MAINTENANCE MANAGEMENT. James K. Jordan. AWWA No. 20252 (1990).
13. NEW DIMENSIONS IN SAFE DRINKING WATER-SECOND EDITION. AWWA No. 20235 (1988).
14. PLAIN TALK ABOUT DRINKING WATER. James M. Symons. AWWA No. 70076 (1991).
15. PUBLIC INFORMATION - HOW TO BUILD A SUCCESSFUL PUBLIC INFORMATION/PUBLIC RELATIONS PROGRAM. AWWA No. 20242 (1989).
16. SAFE DRINKING WATER ACT SERIES:
 - SURFACE WATER TREATMENT RULE. AWWA No. 70055 (1990)
 - PUBLIC NOTIFICATION. AWWA No. 70056 (1990)
 - TOTAL COLIFORM RULE. AWWA No. 70057 (1990)
 - VOC'S AND UNREGULATED CONTAMINANTS. AWWA No. 70058 (1990)
 - LEAD AND COPPER. AWWA No. 70073 (1991)
 - PHASE II: VOC'S, IOC'S, AND SOC'S. AWWA No. 70074 (1991)
17. TREATMENT TECHNIQUES FOR CONTROLLING TRIHALOMETHANE IN DRINKING WATER. AWWA, No. 20221 (1982).
18. WATER CONSERVATION. William O. Maddaus. AWWA No. 20238 (1987)
19. WATER QUALITY AND TREATMENT-FOURTH EDITION. AWWA No. 10053 (1990).

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